Keeping track of the literature isn't easy, so Outside JEB is a monthly feature that reports the most exciting developments in experimental biology. Short articles that have been selected and written by a team of active research scientists highlight the papers that JEB readers can't afford to miss.

Outside JEB

MUTUALISM

A RUB-DOWN FOR STRESSED FISH

There are few cases of different species going out of their way to help one another. Indeed, mutual kindness often ends in acrimonious divorce as one species tries to take more than the other is willing to give. One classic mutualism between species that has withstood the test of time involves a group of fishes called cleaner wrasse and their fish clients. As the name suggests, wrasse clean their clients by eating their ectoparasites. Occasionally, however, they cheat their clients; instead of eating the parasites, they nibble their clients. New research by an international group of scientists led by Marta Soares in Portugal sheds new light on how this mutualism persists despite the selfishness of a handful of wretched wrasse. The answer: a good massage.

What does a cheating wrasse do when caught consuming its client? In fish, as in humans, sometimes an apology is offered. Previous research found that cleaners seek reconciliation while massaging their riled clients with their fins. This 'tactile stimulation' calms clients and keeps them from leaving the cleaning station. However, being caught once does not stop the wrasse from nipping at her client again later. Tactile stimulation has thus been viewed as a form of manipulation, benefiting the wrasse but harming the client. Soares and her colleagues wondered whether there was not more to the story. Might clients submit to cheaters because they get something out of it?

The researchers hypothesized that tactile stimulation was not unlike a human massage: something to enjoy, while at the same time lowering levels of the stress hormone cortisol (with attendant health benefits). To test the effects of tactile stimulation on client fish, the scientists first stressed them by isolation and next determined whether a massage calmed them down. Because wrasse do not offer massages when prompted, Soares and her colleagues built model wrasse masseuses that either massaged or remained stationary.

The team found that the stressed fish spent significantly more time with the moving model than with the stationary model when given the choice. In addition, their cortisol levels dropped in proportion to the time spent contacting the model. The authors have yet to determine whether this physiological change leads to direct health benefits. If it does, however, the current experiments imply that the client profits from the manipulative tactile stimulation of the cheaters. They cool down with a relaxing rubdown while wrasse nibble away at their client's mucus.

Health benefits of massage in fish and man reveal a remarkable continuity in the effects of physical contact in vertebrates. We are unexpectedly tied to our aquatic forebears in our shared enjoyment of a calming touch, even if provided by a wooden model fish.

10.1242/jeb.064089

Soares, M. C., Oliveira, R. F., Ros, A. F. H., Grutter, A. S. and Bshary, R. (2011). Tactile stimulation lowers stress in fish. *Nat. Commun.* **2**, 1-5.

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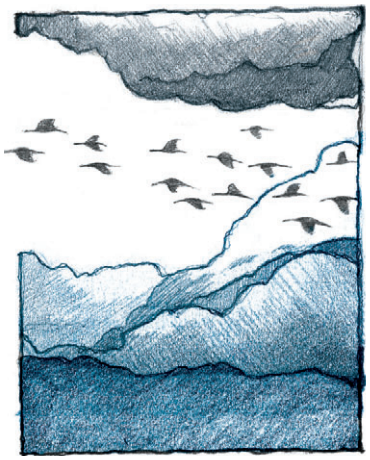
SURVIVAL



BIRDS OF A FEATHER SURVIVE WINTER TOGETHER

From the oracles of Greek antiquity to the crystal balls of druids, the possibility of predicting future events has captured human imagination for millennia. Even modern scientists and wildlife managers are not immune to this desire. For decades, researchers have tried to develop reliable methods for predicting the survival of wild animals. In particular, scientists have attempted to connect mechanistic physiological measurements with subsequent survival. Frustratingly for researchers, most of the parameters measured to date are not reliable predictors of survival. It seems that many physiological parameters are too sensitive to current conditions and are therefore too changeable to be used to predict future survival. However, a recent paper by Lee Koren and colleagues presents a promising method for survival rate prediction. The worldwide team of researchers from Canada, Israel, New Zealand and the United Kingdom used novel hormone measurements to predict survival in wild house sparrows (*Passer domesticus*).

Previous research has attempted to correlate hormone levels with subsequent survival, but with limited success. Koren and colleagues approached the problem differently.

First, hormones in wild animals are typically measured in blood or faecal samples. Such samples reflect current hormone levels and tend to be highly dependent on current conditions, and are therefore highly variable. Instead, Koren and colleagues measured hormone levels in feathers grown after the autumn moult to obtain an incorporated measure of hormone levels during the period of feather growth.

Second, hormones are typically measured using labelled antibodies that bind to a hormone of interest. But antibody binding is inherently inaccurate, as antibodies are never entirely specific to the hormone of interest. In the current study, Koren and colleagues avoided the errors associated with non-specific antibody binding and inaccurate sampling by measuring feather hormone levels with mass spectrometry. Using this novel approach, they showed that feather hormone levels predict the birds' overwinter survival and that birds with lower feather hormone levels are more likely to survive the subsequent winter.

The hormones measured in the study by Koren and colleagues were cortisol, corticosterone and testosterone. Cortisol and corticosterone are associated with the stress response, while testosterone is an important sex hormone. All three hormones are associated with energy use and metabolism in both male and female birds. The team suggests that differences in energetic needs or stored energy reserves during the autumn might be reflected in the feather hormone concentrations and may then influence overwinter survival. Interestingly, while corticosterone is a well-known stress hormone in birds, this paper is one of the first to demonstrate that birds also produce cortisol.

The use of hormone measurements from feather samples to predict survival potentially offers a new tool for wildlife managers to predict the survival of wild animals. Such a tool is a valuable addition to population management and conservation. Forget tea leaves and tarot cards; at least for house sparrows, feather hormones predict the future.

10.1242/jeb.064105

Koren, L., Nakagawa, S., Burke, T., Soma, K. K., Wynne-Edwards, K. E. and Geffen, E. (2011). Non-breeding feather concentrations of testosterone, corticosterone and cortisol are associated with subsequent survival in house sparrows. *Proc. R. Soc. Lond. B* doi: 10.1098/rspb.2011.2062.

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PREY CAPTURE

ROVE BEETLE LIPS STICK TO THE SUBJECT

We tend to think of predators as moving quickly and striking hard. But for many animals, moving quickly and sticking fast is a preferred tactic. Rove beetles (*Stenus* spp.) are a good example of this. They have evolved mouthparts (labia) tipped with a set of sticky pads. When prey wander by, the beetles protrude their labia and reel in a meal stuck to their 'lips'. Rove beetles feed on a wide array of invertebrates, so their prey-capture device must presumably be able to stick to surfaces with a broad range of topologies and moisture levels. What is it about rove beetle lips that allows them to stick to varying surfaces? Lars Koerner, Stanislav Gorb and Oliver Betz at the University of Tubingen and Christian-Albrecht University, Germany, explored this question in a pair of recent papers, one published in the *Journal of Insect Physiology*, the other published in the journal *Zoology*.

First, the team used a combination of force measurements and high-speed video to characterize predatory strikes in two species of rove beetle. In the lab, they lured the animals into launching strikes at insect pins with attached force sensors. They found that in both species, the force of adhesion was much higher than the force of impact. When the team watched high-speed videos of strikes, they could also see that the process is a very wet affair. The sticky pads of both species are slathered in a layer of low viscosity mucus and each strike leaves behind a film of slime. These results show that the prey-capture device is optimized for adhesion and that mucus secretions are involved.

At the same time, the team tested how well beetle labia stick to different types of surfaces. They coaxed beetles into launching strikes at hydrophobic and hydrophilic surfaces and at surfaces with varying levels of roughness. Neither hydrophobicity nor surface roughness influenced the attachment ability of the prey-capture apparatus. This shows that rove beetle lips are indeed well adapted to stick to a diverse array of different surfaces.

Koerner and colleagues then examined labial morphology using electron microscopy. In both species, the labia are tipped with a pair of oval pads. Each pad in turn is composed of hundreds of tiny outgrowths with terminal ramifications (think little ropes with frayed ends). All of these outgrowths are deeply immersed in mucus. This arrangement combines features of dry adhesive systems (multiple contact points, branched morphology) with wet ones (widespread secretions), and probably explains why beetle lips are so good at sticking to different types of surfaces.

The team did a very careful and thorough job of describing both the functional properties and morphology of the prey-capture device. And although they didn't test the idea directly, they provide very strong circumstantial evidence that a mix of features common to dry and wet adhesive systems is what gives rove beetle lips their 'universal stickiness'. Overall, this work is important because it highlights the value of studying species that have evolved unique prey-capture devices. It also shows how much we can learn as biologists by measuring how small animals do seemingly simple things like stick to stuff.

10.1242/jeb.064113

Koerner, L., Gorb, S. N. and Betz, O. (2012). Adhesive performance of the stick–capture apparatus of rove beetles of the genus *Stenus* (Coleoptera, Staphylinidae) toward various surfaces. *J. Insect Physiol.* **58**, 155-163.
Koerner, L., Gorb, S. N. and Betz, O. (2012). Functional morphology and adhesive performance of the stick-capture apparatus of the rove beetles *Stenus spp.* (Coleoptera, Staphylinidae). *Zoology* doi: 10.1016/j.zool.2011.09.006

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WATER STRESS DOWN SOUTH

Life in Antarctica seems like it might be stressful for an insect because of the cold temperatures. But recent work by Nicholas Teets and his colleagues published in the *Journal of Insect Physiology* demonstrates that the lack of water in that habitat can also demand a stiff toll.

During much of the year, water in Antarctica is frozen, so the availability of water is highly variable and insects are vulnerable to dehydration. Yet, insects survive desiccation by accumulating osmoprotectants such as trehalose and glycerol, which the authors hypothesized would exact an energetic cost. As physiological responses to cold stress can alter as the number of exposures increases, Teets and his co-workers tested whether there were differences in the energetic costs between repeated and prolonged dehydration stress in the midge *Belgica Antarctica* – the only insect endemic to the Antarctic continent.

The authors travelled to Palmer Station on the Antarctic Peninsula and collected larvae during the austral summer from the adjacent islands. They then exposed larvae either to five bouts of rapid dehydration followed by rehydration, or to a single 10 day exposure to a slower dehydration followed by rehydration. After each rehydration they measured whole-animal and midgut cell survival, water content and metabolite concentrations (lipids, osmoprotectants and glycogen), to quantify the cost of each type of exposure.

The team found that repeated bouts of dehydration were stressful for the larvae, causing significantly more mortality than a single prolonged dehydration. In addition, the survival of midgut cells was reduced in the repeatedly dehydrated larvae, although one dehydration cycle was just as damaging as five. What the authors didn't expect was that while water content was lower after the dehydration phase of the first few cycles, over the course of the five dehydration/rehydration cycles, the larvae were able to retain more and more of their water during dehydration. This suggested that there were adaptive changes in the insects' ability to prevent water loss during dehydration after multiple occurrences.

They also found that the energetic costs of dehydration differed between larvae that received repeated and prolonged exposures. Repeatedly dehydrated larvae had dramatically decreased glycogen and trehalose reserves, and therefore a lowered carbohydrate energy content after five cycles of dehydration. By contrast, larvae that had been exposed to prolonged dehydration had slightly decreased glycogen levels but their lipid content was also much lower, which resulted in a significantly lower total energy content relative to the larvae that received repeated exposures. The authors suggest this decrease may be due to the insects having a higher metabolic rate during the prolonged dehydration period.

Taken together, these results show that dehydration stress is energetically costly for *B. antarctica* and that the type and amount of energetic cost depends on the frequency and intensity of that stress. As moisture regimes on the Antarctic Peninsula may change as a result of climate change, the costs of dehydration may form an important limit to *B. antarctica* fitness in a changing world.

10.1242/jeb.064097

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